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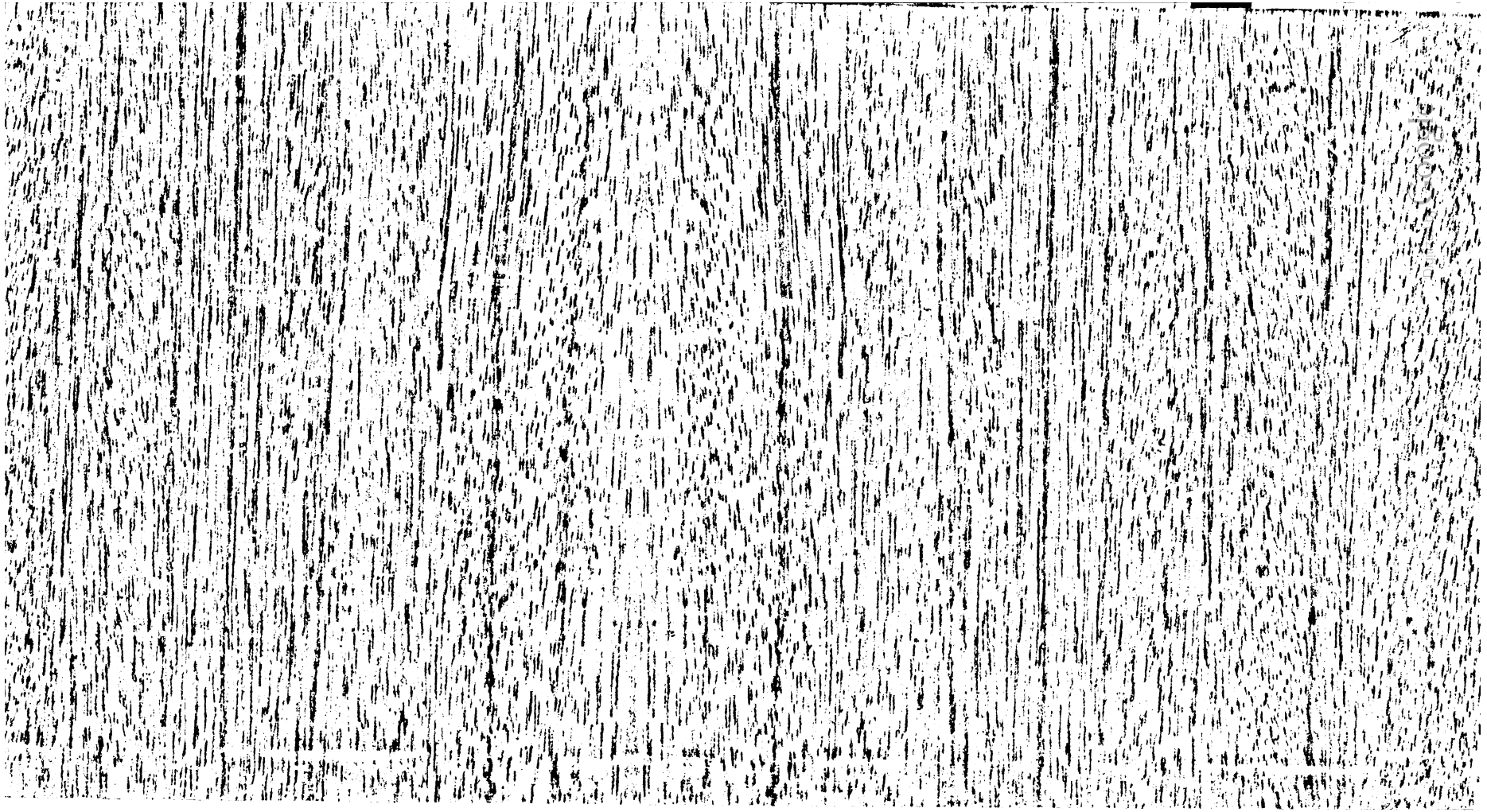

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96 S.E.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY

OF THE

OOLITIC AND LIASSIC ROCKS

TO THE NORTH AND WEST OF MALTON.

(EXPLANATION OF THE QUARTER SHEET 96 S.E. OF THE ONE-INCH GEOLOGICAL SURVEY MAP OF ENGLAND AND WALES.)

BY

C. FOX-STRANGWAYS, F.G.S.

THE LISTS OF FOSSILS REVISED BY

R. ETHERIDGE, F.R.S., PRES. G.S.

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NOTICE.

The formations described in this Memoir are the same as those of which Mr. Strangways gave an account in the Explanation of Quarter Sheets 95 SW. and SE ; with the exception that in the district comprised in 96 SE. the Lower Cretaceous (Neocomian) clays, and the Portland Beds are absent, and the three great divisions of the Lias are present. The Lower Lias is however not seen at the surface, being concealed by superficial deposits.

The whole has been mapped and described by Mr. Strangways with his usual accuracy.

ANDREW C. RAMSAY,

Director-General.

20th August 1881.

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NOTICE.

The tract of country comprised in Quarter Sheet 96 SE. of the Geological Survey Map of England and Wales, of which this Memoir is an Explanation, was surveyed by Mr. C. Fox-Strangways, under the superintendence of Mr. H. H. Howell, District Surveyor.

The rocks described by Mr. Strangways are those lying to the north and north-west of Malton, and mostly belong to the Upper and Middle Oolites; a very small area being occupied by the Chalk on the eastern side of the map, and the Liassic strata occurring in the south-western corner.

The chief point of interest in the Memoir seems to be the remarkable change, both in character and development, of the Middle Oolites in the northern region of Pickering and Helmsley, and in the southern region of the Howardian Hills.

The lists of Fossils have been revised by Mr. Etheridge.

MS. Coloured Copies of the Six-Inch Geological Survey Map of this area are deposited, for reference, in the Geological Survey Office.

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28, Jermyn Street, S.W.,
17th August, 1881.

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THE GEOLOGY

OF

THE OOLITIC AND LIASSIC ROCKS

TO THE NORTH AND WEST OF MALTON.

Introduction.

The outcrop of the rocks in the northern part of the map is really a continuation of that to the east, in 95 S.W., and consequently this pamphlet should be read in conjunction with the one describing that sheet.

The area contained in the map is 216 square miles, and includes the western end of the great hollow known as the Vale of Pickering. The principal towns are Malton, Pickering, Kirkby Moorside and Helmsley, which are situated on the flanks of the valley just where the hills begin to rise on either side. There are also nearly 40 villages of considerable importance situated within the map, besides several smaller hamlets.

Nearly the whole of the area is drained by the river Rye and its tributaries, the waters of which enter the Derwent on the eastern edge of the map, and then flow south through the gorge below Malton. The south-west corner, including an area of about 13 square miles, is drained by the little river Foss, which enters the Ouse at the City of York.

The physical features of the district may be said roughly to assume the shape of a horseshoe, the most elevated ground ranging along the north, west, and south sides of the map, while the centre is either comparatively flat or occupied by hills of but slight elevation, and as we shall show presently, the various groups of strata follow the semicular form of the hills.

The most elevated areas are the Moors in the north-west corner, which exceed 1,000 feet in height; while the level of the Derwent, where it leaves the map a little south of Malton, is not more that 50 feet above the sea.

The rocks coming to the surface in this district mainly belong to the Upper, Middle and Lower Oolites; besides these a very small patch of Chalk, which forms the north-west corner of the Yorkshire Wolds, enters the map on the eastern side, and the Liassic rocks are found in the south-west corner.

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Geological Formations.

The following are the geological formations which occur in the district :—

Table of Formations.

Recent and Post Glacial	Alluvium. Warp and Lacustrine Clay. Sand and Gravel.
Glacial	Boulder Clay and Gravel.
Upper Cretaceous	White Chalk. Red Chalk.
Upper Oolite	Kimeridge Clay.
Middle Oolites	Upper Calcareous Grit. Coral Rag and Upper Limestone. Middle Calcareous Grit. Lower Limestone. Passage Beds. Lower Calcareous Grit. Oxford Clay. Kellaways Rock.
Lower Oolites	Cornbrash. Upper Estuarine Series. Scarborough or Grey Limestone Series including the "Brandsby Roadstone." Middle Estuarine Series. Millepore Series, including the "Whitwell Oolite." Lower Estuarine Series, with beds of Hydraulic Limestone. Dogger.
Lias	Upper Lias. Middle Lias. Lower Lias.

The Lias.

The Liassic Rocks occupy a small portion of the south-west corner of the map, covering an area of about eight square miles; they are much obscured by Boulder Clay and Gravel, and are apparently somewhat faulted, from which causes the mapping of the lower portion is rather uncertain.

The Lower Lias.—Except quite the uppermost portion, these beds are not seen anywhere in this district, being buried by a great thickness of Boulder Clay and Gravel, which in wells between Stillington and Brandsby has been proved to have a thickness of about 20 yards. Judging from neighbouring areas it probably consists of dark blue shales with ironstone bands and doggers in the upper part, and hard bands of limestone full of fossils in the lower.

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These beds occupy the low ground south of Brandsby, but are only exposed in a few drains near Stearsby and Skewsby. The thickness of the Lower Lias in this neighbourhood we have at present no means of estimating.

The Middle Lias.—This portion of the Lias consists in the main of sandy shales and sandstones with calciferous doggers full of fossils, of which the principal are *Rhynchonella tetrahedra Avicula inæquivalvis, Exogyra Maccullochii, Pecten æquivalvis, Cardium truncatum, Hypopodium, Isocardia, Myacites*, etc. Above this is a greater or less thickness of soft shale with bands of ironstone doggers.

These beds have a thickness of about 70 feet, and being considerably harder than either the beds above or below, form a well marked terrace along the hillside from Brandsby eastwards ; west of Brandsby they are depressed by a fault and crop out in the low ground, but are only obscurely seen west of Britton Wood.

Around the hill at Crayke the Middle Lias also forms a fairly well marked terrace; the beds are seen at a few places, and are also proved in the numerous wells about the village.

The Upper Lias.—This consists of shales somewhat harder than those of the Lower Lias, but softer than the beds of the Middle Lias, above which it usually rises in a steep bank, and from either of which it is easily distinguished.

The thickness of the Upper Lias is about 80 feet; it forms a steep clayey bank along the hillside east of Brandsby, but west of that village it has not been seen anywhere, being entirely concealed by Boulder Clay.

An outlier of these shales occurs on the hill at Crayke; they are exposed in the roadside immediately below the Castle, and there is also a faulted portion to the south where the lower part with *Inoceramus dubius* is seen on the side of the road leading to Easingwold.

There must also be an inlier of Upper Lias below the Oolite north of Wiganthorpe, brought up by the great east and west fault near that place ; although the beds here are not really seen in situ their presence is inferred by the boggy ground and springs below the Dogger beds of the Inferior Oolite at Swinsey Carr near Wiganthorpe.

LOWER OOLITES.

The principal portion of the Lower Oolites which crops out in this map is that in the south west, forming a portion of the Howardian range of hills. The Upper Estuarine beds also crop out in the bottom of the valleys of the Rye, Riccal, and Hodge Beck, but they occupy a very small area in this map, and really belong to larger spreads that outcrop on the moors to the north, and which will be treated of in describing that country.

The lithological character and thickness of this southern portion differs considerably from that described in the east and north,

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and indicate a great dissimilarity in the physical conditions under which they were deposited. The beds on the whole consist of a great sandy series with four or five variable beds of calcareous sandstone or impure limestone occurring on certain horizons.

Their total thickness is about 450 feet, but I have not much evidence to fix their upper limit with any exactitude.

The Dogger.—This, which is the old name given to the marine bed at the base of the Oolites, is lithologically a rather curious mixture, being in part a ferruginous conglomerate, in part a ferruginous and oolitic limestone, in part a ferruginous sandstone, and in part an arenaceous ironstone. It is rather an irregular bed, and thickens out or dies away in very short distances, and it is not until we get to the neighbourhood of Terrington that it becomes of sufficient importance to map.

Just below the trigonometrical station, nearly a mile west of Terrington, is the first good exposure in this rock. The section seen here is—

	ft.	in.
Rubbly bed of sandstone with pebbles or concretions - - - - -	4	0
Ferruginous limestone, lower part not seen -	7	0

At the village the Dogger either dies out or is so thin as not to be recognizable; but further south it comes on again in considerable force as a ferruginous and oolitic limestone, which is quarried at several places to a depth of from 9 to 13 feet.

There is a small inlier of this rock brought up by the fault north of Wiganthorpe House, which is seen on the roadside at Swinsey Carr, where a few feet of ferruginous sandstone, with fossils and the usual pebbly concretions, repose on a thin bed of impure ferruginous limestone.

The Lower Estuarine Series.—These beds consist principally of soft sandstone usually much falsebedded and containing small irony concretions; towards the upper part they become more shaly and form heavy clay land requiring much draining.

The series is chiefly remarkable from its containing in its upper portion one or two well marked beds of cement stone or hydraulic limestone associated with a bed of ironstone. Throughout a portion of the district there are two beds of this limestone separated from each other by a few feet of shale. The upper of these beds, which is only two feet thick at Maidensworth, is not always present, and its outcrop is too obscure to be traced on the map; it is therefore with the lower bed that we are principally concerned.

This bed of limestone, which is the one shown on the map, has a thickness of about four feet; it is a hard close-grained argillaceous limestone with a conchoidal fracture, and contains a few fossils, which, however, usually break transversely, and are therefore

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difficult of extraction and determination. A freshly broken surface of the stone is of a light greyish blue colour, but on exposure to the air it becomes white. Below the limestone is a bed of ironstone very full of fossils, of which the principal are *Unicardium globosum, Ostrea gregaria* ?, *Myacites, Rhynchonella.*

The hydraulic limestone has been burnt for lime at several places in the neighbourhood of Terrington, and is said to make very good lime for agricultural purposes; it is also frequently used as a roadstone.

The limestone outcrops in most of the valleys west and south of Gilling Park, being seen in Newborough Park, on Yearsley Moor, below Grimston, Scackleton, Howthorpe, and along the southern escarpment to the neighbourhood of Terrington, where it is interrupted by a fault for a short distance, but outcrops again in the side of the bank west and south of Ganthorpe. A well at Moorhouses near Terrington is said to have gone through both beds of this limestone.

In this series of measures occurs one of the coal seams of the Lower Oolite. It is many years since it was worked, and I was not able to gather any reliable information as to its thickness, which is said to vary from 1 to 4 feet, but I think the latter estimate is rather doubtful. The old pit heaps are to be seen on the sides of the becks on the north of Yearsley Moor and Grimston Moor, where it appears to have been worked mainly at its outcrop.

The Millepore Bed. (Whitwell Oolite.)—Above the beds just described is a siliceous limestone, oolitic in part, which becomes thicker and more oolitic as we trace it eastwards. This bed, which from its dying out to the north, cannot be traced absolutely to join with the Millepore Bed of the Coast, is however correlated with it from the evidence of the large collection of fossils that have been made at Whitwell in the next map (93 N.E.), where this rock attains its typical development. In the present district the Millepore Bed consists of hard siliceous limestone with fossils, in large blocks, which occasionally stand out in large tabular masses overhanging the softer beds below; the lower part of the formation is a much purer limestone and more oolitic, but the oolitic structure does not seem to be always developed to an equal amount. Below the oolite are usually a few feet more of the siliceous beds which towards their base pass into softer sandstone.

The thickness of these beds varies somewhat, in Newborough Park there is only about 10 feet of them, while at Terrington there must be 20 feet or more, but there is no complete section in which the thickness can be measured.

The Millepore Bed crops out very regularly on the northern side of the Howardian Hills, from Newborough Park to Grimston Moor, and again on the southern escarpment as far as Brandsby, where it is thrown up by a fault, so as to form outliers at High Wood and Dalby; east of this the outcrop has a more or less

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interrupted course by Terrington to Ganthorpe. In the centre of the district this bed outcrops on either side of the valley south of Colton, at several places between this and Airyholme, and thence runs in an uninterrupted line on the north side of the fault to beyond Coneysthorpe.

The Middle Estuarine Series.—The Middle Estuarine beds are on the whole very sandy, and form very poor ground which requires to be well marled to bring it into cultivation. The upper part is more clayey, and at Grimston it has been dug for spreading over the sandy ground below.

The following section, which has a very coal-measure aspect, was measured at this place.

Marl Pit, Grimston Moor.

	ft.	ins.
Little Sandstone (irregularly bedded)	—	
Brown Shale	2	0
Dark shale with sandy streaks	0	8
Light-coloured sandy shale, with a little sandstone here and there	4	6
Dark carbonaceous shale	0	4
White sandy clay with vertical stigmaria	0	10
Hidden by talus	4	0
Thin seam of coal on floor of working	—	

The total thickness of these beds appears to be about 60 feet; they form large spreads in Newborough Park, and on Grimston Moor, but thin away to the eastward, and near Terrington are not more than from 30 to 40 feet thick.

The Scarborough or Grey Limestone Series. (Brandsby Roadstone).—This formation, which is the equivalent of the Scarborough or Grey Limestone Series of the Coast, is better known in this district as the "Brandsby Roadstone," it having been quarried for a great number of years at Brandsby as a material for mending roads, and from which place extensive collections of fossils have been made.* It is a hard siliceous limestone splitting up into large slabs, in fact some of the beds are so fissile as to afford roofing slates, for which purpose it was largely used in former years; the upper portion of the rock is a brown porous grit, very full of casts of *Avicula Braamburiensis.* It is very frequently only this upper grit which is exposed, the limestone below being decomposed into soft sand, and not making any feature.

The total thickness of these beds is probably about 40 feet, but of this there will not be more than about 20 feet belonging to the limestone.

The largest spread of this rock is on the summit of the hill about Yearsley, where it occupies nearly all the high ground between Newborough Park and Brandsby, it also outcrops in the

* There is a very fine series of fossils from this locality in the York Museum, collected by the late Mr. Cooke, of York.

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higher part of Newborough Park and at Park House; after this it is much broken up by faults into several isolated patches, which are seen near Redcar House below Gilling Park, between the faults north of Grimston Moor to Hovingham Lodge, and thence at the foot of the Middle Oolite escarpment across Slingsby Moor. The outcrop is also repeated at Wiganthorpe and in the low ground north of Terrington by the great east and west fault north of those places.

The Upper Estuarine Series.—These beds are of very little importance, they are mostly sand which towards the base becomes more solid, and in a few places is almost a grit, the upper portion is however rather more clayey. This series crops out in the valleys of Hodge Beck, Riccal, and Rye, along the northern edge of the map, where its base is represented by a thick bed of grit, the Moor Grit of the country to the north. In the south the beds form outliers in Newborough Park, at Yearsley, and at Brandsby; they also crop out in the low ground north of the fault across Yearsley Moor, between the faults south of Sike Gate, and west of Hovingham High Wood, as far as Hovingham Lodge; beyond this they are cut out by the fault as far as Wath Beck, after which they again form a tract of sandy land by Gay's Hall and Slingsby Moor until they meet the fault north of Coneysthorpe.

To the north of Terrington there is a portion of these beds repeated below the Calcareous Grit escarpment of Cumhag Wood.

Cornbrash.—The Cornbrash crops out in the valleys of the Hodge Beck, Riccal, and Rye on the North of the map; it is seen at a few places in these valleys, but the best sections of the rock are to the north in the neighbourhood of Hutton-le-Hole and Lastingham. It is a ferruginous limestone very full of fossils, having a thickness of about two feet.

In the Howardian Hills the Cornbrash is not mapped, as I am unable to say whether it is represented or not; I do not know of a single section exactly on this horizon, but it is very evident that it does not exist as a hard rock, otherwise some fragments of it must have been discovered along the extended outcrop of strata at about this horizon.

At Shaken Bridge on the Rye the Cornbrash was some years ago tried as an ironstone, but apparently without much success, and the workings were soon abandoned.

Middle Oolites.

Kellaways Rock.—This rock in the north of the map has a thickness of from 70 to 80 feet; it is a tolerably massive sandstone which is ferruginous and fossiliferous in the upper part. At Coney Birks, in the valley of the Riccal, the rock becomes quite a coarse grit, and covers the hill-side with large fallen blocks, one of which measured 27 feet in length by 9 feet in breadth.

The Kellaways Rock outcrops in the east branch of the Pickering Beck, called Levisham Beck, at Beck Houses in the Seven Valley, and in the valleys of the Hodge Beck, Riccal, and Rye.

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In the southern area the Kellaways Rock is not well seen; it enters the map to the west of Ampleforth where it is completely obscured by the talus from the hill-side, but judging from the country further to the west it is probable that the rock is of no great thickness, and that it occurs merely as a sandy band in the midst of the Oxford Clay.

Below Gilling Park and Hovingham High Wood it must also be very thin, and is masked by the greater preponderance of clayey ground both above and below; it is even doubtful if it exists about here, but an outcrop is drawn on the map as there is no positive evidence of the bed dying out, and it becomes stronger again a little farther east.

On the side of the projecting knoll, immediately east of Wath Beck, the rock is seen cropping out: it is here very siliceous and stands out from the hill as a large slab; from this point it outcrops along the foot of the bank forming a belt of sandy ground which has been denuded into a series of little "nabs" in the same characteristic manner as the Kellaways Rock near the Coast. This sandy feature is well marked on Slingsby Moor, and less distinctly at the foot of Coneysthorpe Banks Wood as far as the fault below Easthorpe Farm; by this fault it is thrown down and crops out again at the foot of Cumhag and Owlers Woods, where it has the same tendency to form little sand hillocks or nabs, which are strikingly shown on the map by the crenulated line representing the base of the rock below Fryton Wood and near Ling Hills.

Oxford Clay.—The sandy shales of the Oxford Clay retain much the same character as in the eastern part of the county, being far more sandy than the Oxford Clay of the south of England, and also containing fewer fossils. In the Howardian Hills, however, these beds are less sandy than in the northern valleys, and form wet clayey slopes generally devoted to woodlands.

The general thickness of the Oxford Clay in the north of the map is about 80 feet, but in the Howardian Hills it seems to get rather less, and in fact the whole Oxfordian Series (Oxford Clay and Kellaways Rock,) cannot be any more than this.

The Oxford Clay crops out in the seven main valleys in the northern part of the map, where it forms the steep slope between the feature formed by the Kellaways rock and the escarpment of the Calcareous Grit. The best sections in the shales are at Farwath Bridge in the gorge above Pickering, in the bed of the stream about Cropton Mills, and a large natural section at Hutton-le-Hole; there are also exposures of these beds in the streams of the River Dove, the Hodge Beck, the Riccal and the Rye.

In the southern district the Oxford Clay again enters the map and crops out in the steep slopes at and west of Ampleforth; it is not well seen here being entirely obscured by the talus of the Calcareous Grit above. Just west of the village these beds are truncated by the large east and west fault, but appear again on

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the other side of the valley being thrown up by the second of the great trough faults below Gilling Park; east of this they are faulted down and do not crop out until we come to Hovingham High Wood, beyond which there is a tolerably regular outcrop as far as Hildenley, with the exception of slight shifts of the beds at Wath Beck and Easthorpe.

Behind the house at Hildenley are some shales which from their lithological character are supposed to belong to this formation, and for this reason a narrow strip is drawn on the map between the faults past this point. The beds are much disturbed about here, and it is quite possible that the shales may represent something much higher in the geological scale.

In the steep bank below the Park, west of Coneysthorpe, there is another outcrop of Oxford Clay cut off by faults on either side.

The Oxford Clay is not of much economic value, but at Wool Knoll it has been worked for making bricks.

The remaining divisions of the Middle Oolites are so very different in character and in general development in the north of the map to what they are in the south, that it will be better in describing them to take the two areas separately. This is also necessary, as the exact correlation of different horizons at Malton with those in the north is not always satisfactory.

The Northern Region (Pickering and Helmsley).

The Lower Calcareous Grit.—This is the principal rock of the Middle Oolite series; it has a thickness of nearly 150 feet, and consists in the main of a massive sandstone passing gradually into the shales of the Oxford Clay in its lower portion, but becoming more calcareous in its upper part till it passes into the true limestone above.

In the north-western part of the map the Lower Calcareous Grit is much cut up by cherty layers and impure siliceous limestones which cover the ground with white fragments, giving it something the appearance of a chalk country; this is especially remarkable on Rievaulx Moor and on the slopes of the gorges of the Riccal and the Rye.

In this area towards the top of the formation there is a well-marked line of balls or siliceous concretions lying in soft sandy beds, similar to those observed at Scarborough and elsewhere; this peculiarity I have not observed in the Howardian Hills, except in a quarry near Hovingham, where something of this structure seems to be set up.

The Lower Calcareous Grit forms a series of bold headlands facing the north just beyond the northern limit of the map, which are a continuation of the great tabular range mentioned in the country to the east. It dips to the south and is exposed in the sides of the several dales in this part of the map, and forms a large spread on Rievaulx Moor.

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A few miles beyond the north-west corner of the map the outcrop curves round towards the south, forming the great table land of the Hambleton Hills, which attain an altitude of 1,300 feet above sea level. About Ampleforth these beds again enter the map under consideration where they form a bold escarpment facing the south, and, extending as far as Oswaldkirk, are lost against the great fault at the foot of this range of hills. In this part of its course the Lower Calcareous Grit is scarcely divisable from the sandstones of the Middle Calcareous Grit above, the intervening limestone having all but died away.

Beyond Oswaldkirk the Calcareous Grit is cut out for a time, but appears again for a short space about Stonegrave; it is, however, not well seen here, the greater part of the escarpment being formed of limestone repeated by the fault in the bank side. On the opposite side of the valley the Calcareous Grit forms the picturesque nose of Gilling Park, and outcrops along the hill-edge to the east as far as Easthorpe and Malton, forming the bold wooded escarpments of Hovingham High Wood, Coneysthorpe Banks Wood, and Castle Howard Park, but this region will be treated of again presently.

The Passage Beds. — These beds, which form so marked an horizon in the country to the east, seem to be dying out as a distinct series in this map; they are, however, well seen along the north, and can be recognized and mapped as a distinct bed as far west as the Hodge Beck. Beyond this they appear to become merged into the great mass of flinty strata which set in at the top of the Lower Calcareous Grit, and pass up into the limestone. The Passage Beds lithologically most resemble the same rocks nearer the coast, except perhaps that they are less ferruginous and rather more massive in character; they contain large specimens of *Gervillia aviculoides*, *Pecten subfibrosus*, and a few other fossils in great abundance.

The harder bands of this series are largely used for walling or building purposes wherever they occur. These beds crop out on the hill edge above Pickering Beck, where it is joined by Levisham Beck; they usually form a hard edge, and in some cases even a line of crags, which is, however, liable to crumble away from the tendency of the rock to decompose and turn into sand, causing a great deal of the land along its outcrop to be of a very sandy nature.

The outcrop continues as a thin sandy band by Newton in the next map, to Cropton, where it is quarried at several places, and is well seen on the side of the road going down to Rosedale.

On the other side of the valley these beds are continued by Hamley to Spaunton, just beyond which they are depressed by a fault throwing the outcrop to the north, so that they appear at the edge of the escarpment at Riccal Head, and form the fine tabular hills on either side of Hutton-le-Hole. At Gillamoor the Passage Beds are still recognizable, and quarries are opened out in them, but the boundary lines dividing them from the Calcareous

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Grit below and the limestone above are becoming very uncertain, and further west they cannot be separated.

The Lower Limestone.—The Lower Limestone covers the largest area of any rock that crops out along the northern range of hills, and it also attains its maximum development in this district. It enters the map on the high ground above Thornton Dale, and is exposed in several quarries. It is here somewhat fossiliferous, and contains corals, which seem to link it with the Lower Coral Rag of Hackness, described in the Memoir on that sheet (95N.W.) The Oolite has here a dip to the south of from 5 to 6 degrees into the great fault which bounds these rocks on the south.

In the valley north of Pickering the Lower Limestone has a very extended outcrop; it is first exposed in the bottom of the valley, where the road to Newton crosses the railroad, and, rising gradually to the north-east, forms a narrow band in the steep wooded banks on either side till some distance beyond Kingthorpe, when it spreads out over the surface, and may be traced uninterruptedly to Cropton. It is largely quarried in this region, especially at the latter village, where this bed and the Passage Beds below attain a considerable thickness, and are well worthy of study.

On the further side of the valley of the Seven the Lower Limestone spreads out over a considerable area between Spaunton and Appleton-le-Moor, and is exposed in several good sections in the sides of Hutton Beck and the valley of the Dove. The former of these valleys is one of the best localities for studying the Middle Oolites. The beck is usually dry for a great part of the year, and at one point or another presents sections of nearly every portion of the group.

The following section was measured in the quarry on Hutton Common :—

	ft.	in.
Yellow sandstone (base only seen)	—	
Earthy limestone with *Gervillia aviculoides*	6	0
Hard grey limestone	2	6
Shaly limestone	2	6
Thick bed of limestone full of *Ostrea gregaria*	2	0
Thick bed of limestone	2	0
Cherty nodules	1	6
Hard grey limestone	1	0
Cherty nodules	0	9
Hard cherty limestone rich in fossils, *Nucleolites scutatus, Gervillia aviculoides, Ostrea gregaria, Ostrea nana, Chemnitzia Heddingtonensis, Cylindrites elongatus* and *Nerinæa*	11	4

On the further side of Dowthwaite Dale, near Gillamoor, there are some large quarries in this oolite which expose a section of nearly 60 feet, and as this is not the full thickness of the rock, it must here attain a very great, if not its maximum, development. West of this the limestone becomes very siliceous, and covers a large area of poorish land north of Pockley and Helmsley. A curious feature in this part of the country is the great quantity

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of white siliceous fragments which strew the sides of the dales, more particularly Riccal Dale, giving them the appearance of Chalk escarpments.

Beyond the Rye the Lower Limestone becomes much thinner, and splits into two beds, the lower of which is seen half way up the wooded banks south of Rievaulx Bridge; the upper bed follows a line of enclosures across Scawton Moor, but is not traceable east of Waterloo Plantation. The lower bed of limestone, or the amalgamated representative of the two beds, is seen in the bed of the river Rye at Sproxton Mill, and below Duncombe House; it is here a thin impure limestone, and appears to be nearly dying out. Above Ampleforth this limestone can be scarcely said to exist, but there are about 6 feet of impure limestone, with oolitic grains, on this horizon, which serve to mark the division between the Lower and Middle Calcareous Grit. The fields above the village are also said to be more calcareous, and the land better, along the outcrop of this bed.

The Middle Calcareous Grit.—This rock is best seen at Pickering, in the quarries below the castle, where some of the beds have been worked as a freestone for a number of years. It here has a thickness of about 40 feet, but it is only the upper portion which is exposed in the quarries.

It consists, in the upper part of impure limestone and calcareous beds with pockets and irregular bands crowded with fossils, of which the commonest are *Trigonia perlata, Nerinæa visurgis, Astarte Duboisiana,* and corals; the lower part of the rock consists mostly of soft sandstones with but few fossils, except quite at the base, where a somewhat fossiliferous horizon sets in again.

The following section was measured in the quarry below Pickering Castle:

	ft.	in.
Solid beds of limestone with *Chemnitzia Heddingtonensis*	5	6
Rubbly oolite with coarse pisolitic bed	4	0
Thick irregular bed of limestone	2	6
Oolite with irregular blue-centred limestone, containing *Trigonia perlata*	4	0
Thin bed full of *Trigonia perlata*	0	6
Smooth limestone	1	0
Impure limestone with *Trigonia* bands	5	4
Soft yellow freestones with calcareous bands, containing *Exogyra mima, Gervillia aviculoides, Pecten fibrosus, Cardium, Trigonia costata, Trigonia clavellata, Chemnitzia, Ammonites biplex*	11	0

The Middle Calcareous Grit first enters the map on the high ground west and north of Thornton Dale; its outcrop at first is rather obscure and liable to be confused with that of the Upper Calcareous Grit against which it is brought by a fault, it however spreads out on the hill tops to the north of Kingthorpe, and on the opposite side of Pickering Beck extends westwards as a broad band of poor sandy land by Blansby Park and Middleton Heights to the south of Cropton.

It is seen in a few places in the sides of the Seven Valley, and extends in a somewhat obscure course by the north of Appleton to Hutton Beck.

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In this beck a very fine section of the rock is again exposed, extending for nearly a mile along the bed and sides of this stream. Some very fine slabs with *Trigonia* are to be seen here, but a great portion of the rock is a sandstone poor in fossils.

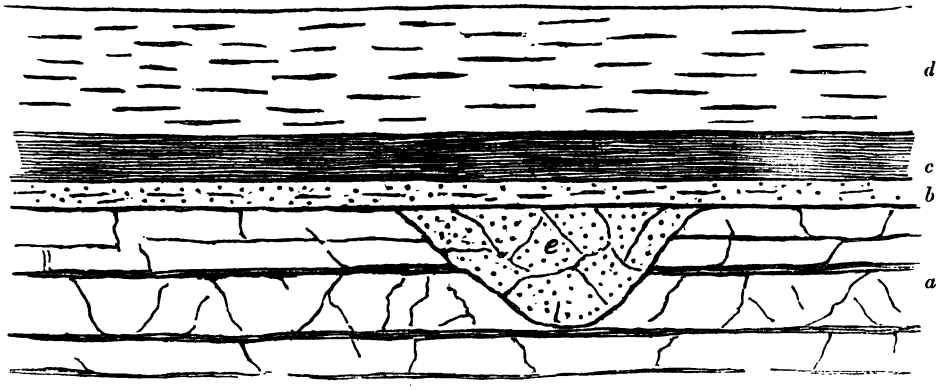
To the north of Kirkby Moorside this rock forms a somewhat large spread by Cockpit Hall and Woolah House; it is well seen in Kirkdale, opposite the Church, but west of this the outcrop becomes more obscure although it may be still recognized in Riccal Dale, and to the north of Helmsley. Here the Middle Calcareous Grit appears to be becoming thinner, but it rapidly thickens again to the north, for just south of the town, in the banks of the Rye below Duncombe Park, there are nearly 80 feet of this rock which has been quarried below the House, and in Quarry Bank Wood, near Rievaulx.

South of the Rye the Middle Calcareous Grit forms a great spread of barren land on Wass Moor and Sproxton Moor to the hill edge above Ampleforth.

In a quarry on Wass Moor, of which a woodcut is given below, there is a curious section showing that the lower limestone was exposed to denudation before the deposition of the Calcareous Grit above.

FIG. 1.

Limestone Quarry on Wass Moor.



a. Oolitic Limestone. whitish streaks at bottom. *b.* Reddish Sandstone. *c.* Dark carbonaceous matter, with *d.* Red Clay. *e.* Sandstone, filling old erosion in Oolitic Limestone, much fractured.

The Upper Limestone.—This limestone is also splendidly exposed in the fine series of quarries at Pickering, which are opened out just above those for the freestone of the Middle Calcareous Grit. It has a thickness of about 50 feet, and consists principally of massive beds of limestone which are largely quarried for lime-burning, and as a flux for smelting the iron ore in the furnaces of north Yorkshire.

On certain horizons these limestones are very fossiliferous, the principal fossils being *Ostrea, Pecten, Astarte ovata, Chemitzia*

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Heddingtonensis, Nerinæa, Phasianella striata, etc.; towards the base of the series there is a marked bed of pisolite of which the grains are as large as small beans; the upper part of the limestone is more bituminous and has acquired the local name of "black posts," it is from about this horizon, or just above, that most of the limestone is obtained which is sent to the iron furnaces. Resting on the top of the limestone beds there is a peculiar argillaceous limestone, with a conchoidal fracture, to which the local name of "throstler" has been applied. It is not, at the most, more than four feet thick, but has a very irregular outcrop, and does not appear to be always present.*

The Upper Limestone is first seen in a quarry on the hill west of Thornton Dale. It does not appear to be so thick here as at Pickering, and the outcrop being broken by faults, can be but obscurely traced over the ground known as High Fields.

In Howl Dale, however, the bed becomes more distinct and can be followed along the bank on both sides of that dale. Near Hagg House the limestone is quarried for road metal; it is here mostly a hard blue rock with a marked band of Oolite in the upper part.

Beyond Howl Dale the outcrop of the limestone turns round by Kingthorpe into the Pickering valley, it is well exposed in the sides of this gorge, and on the west side forms a considerable spread over Blansby Park and on the hill side above Middleton, Aislaby and Wrelton to the gorge at Sinnington. At this latter place there is a magnificent section along the side of the river just north of the village which shows the whole of this series together with the grits both above and below. There is a large fault in the valley here which depresses the limestone to the west, so that it crops out in the bed of the river, and also on the hill-top at Appleton-le-Moor, a difference of about 200 feet.†

In Hutton Beck there is again a fine section in these beds, showing a considerable thickness of Coral Rag and Chemnitzia Limestones, the details of which are given below.

Section in Hutton Beck.

	ft.	in.
Ochrey sandy beds - - - - - -	—	
Hard grey fossiliferous limestone with ringed *Serpula Cladophyllia, Montlivaltia dispar, Cidaris florigemma, Cidaris Smithii, Ostrea bullata, Exogyra, Astarte ovalis, Cerithium muricatum,* and *Littorina muricata* - -	3	8
Thick bed of denser limestone with *Pseudodiadema, Cidaris,* and *Belemnites* - - - - -	2	8
Flaggy earthy beds, much used for walling, passing down into limestone, containing corals in some places -	10	0
Coarsely oolitic bed with masses of *Cladophyllia* and *Rhabdophyllia. Trigonia* towards the base, which is irregularly bedded - - - - - -	2	6
Cherty fossiliferous limestone with *Chemnitzia Heddingtonensis* - - - - - - -	16	0

* Mr. Hudleston classes this bed with the division above, the Upper Calcareous Grit. *Quart. Journ. Geol. Soc.,* Vol. XXXIII., p. 335.

† This, on account of the dip of the beds, is more than the real throw of the fault. Vide p. 33.

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Beyond Hutton Beck the Upper Limestone forms a narrow strip to the north of Kirkby Moorside, by Pockley to the neighbourhood of Helmsley. There are numerous quarries opened in the rock throughout this region, and it is also well exposed in the sides of the several gorges through which the moorland streams reach the Vale of Pickering.

In a quarry near the roadside at Kirkdale are the remains of the famous Kirkdale Cave in which were found the bones of no less than 27 species of Mammalia and Birds. The cave, which has now been mostly quarried away, is situated about half way up the face of the quarry along an irregular line formed at the junction of the Chemnitzia limestones with the more earthy limestones above; the upper surface of the Chemnitzia limestones throughout this region is very hummocky, and is known to the quarrymen of Pickering and Hutton by the name of "hilly and holey;" on this irregular surface repose the more earthy limestones above with soft marly partings which are easily worked away and form the cave line throughout the district. It is probable that at this horizon in the limestone are formed the numerous "swallows" or underground channels, in which most of the streams in the neighbourhood lose a part or all of their water, and if the denudation of these valleys was carried 100 feet lower, it is probable that a fine series of caves would be exposed in this region.

In the neighbourhood of Helmsley the outcrop of the limestone is broken by an east and west fault, having a downthrow to the south which brings in a large spread of the rock over Duncombe Park to the west of the town.

On the south side of the Rye the limestone forms a steep bank along the river for some distance; it here appears to be getting more siliceous, and in several of the quarries is very flinty. The rock may be traced along the steep bank facing Duncombe Park, and through the Park to Sproxton Quarry; from this point the general direction of the outcrop, which is interrupted by the numerous dry valleys coming down from the Moor, turns south to Beacon House on the hill top above Ampleforth College. At this point the outcrop trends east and is quarried along the edge of the escarpment in several places. The Coral Rag portion of the Limestone is here well developed and contains very fine *Thecosmilia* in position of growth, and *Isastræa*. The Limestone at this point attains its greatest elevation, about 690 feet, but rapidly falls away to the east, so that at Oswaldkirk it is only 300 feet, and at Nannington cutting only 200 feet above sea level, it however rises again in Cauklass Bank to the 300 contour.

At Oswaldkirk the limestone is quarried at several places and has a thickness of about 50 feet, but beyond this it becomes truncated by the great east and west fault which brings in the Kimeridge Clay on the south, so that at Laysthorpe Lodge only a very few feet are seen, the greater part of the hillside being clay. In the hollow, however, through which the railway to Helmsley runs, the full thickness appears again and a good section is exposed in the railway and quarry close by; the limestone is here

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much shattered, and has large fissures probably caused by its proximity to the Stonegrave faults.

At Stonegrave the limestone forms a large spread on the hill top, and is also quarried in the bank side at the village and at the side of the road going up to Nunnington. The stratigraphy is here exceedingly obscure, and it is probable that the outcrop of the Limestone is repeated by a fault in the hillside, otherwise the thickness would be too great as we have limestone nearly at the 175 feet contour and also at the 300 feet which would give more than 100 feet, or what is twice the usual thickness in this district.

A noticeable fact in the limestone about here is the great abundance of corals *Thamnastræa, Thecosmilia*, and *Cladophyllia*, there is also a peculiar shaly band about a foot thick exposed in some of the quarries in this region.

At the base of the limestone in this district, that is from Ampleforth to Cauklass, there is a peculiar band of rock consisting of impure gritty beds with oolitic grains; it has a thickness of only a few feet, and constitutes a sort of passage bed from the Calcareous Grit into the Limestone above. These beds stratigraphically are at a higher horizon than the Passage Beds previously mentioned at the base of the Lower Limestone as can be seen by following up the road from Ampleforth village to Beacon House, which passes successively over the Lower Calcareous Grit, the cherty representative of the Lower Limestone and a considerable thickness of Middle Calcareous Grit before coming to these beds. These beds are best seen below the old tree in Oswaldkirk Bank and close to the Inn at Stonegrave, they also outcrop generally at the base of the Limestone throughout the Howardian Hills, although they are too thin to represent on the map.

The Upper Calcareous Grit.—The Upper Calcareous Grit is somewhat dissimilar to the Lower and Middle divisions previously described, being rather redder in colour and sharper or more rough in texture. In the neighbourhood of Pickering it is known as the "Red rock," and has a thickness of over 30 feet; it is full of forms resembling fucoids, which, falling into fissures in the limestone below, have been istaken for bones. This rock outcrops to the west of Thornton Dale at High Fields, and is exposed in many places in the lanes and quarries between here and Pickering. It forms a large spread on Scalla Moor and above Middleton. At Sinnington it is cut by the fault at that place, so that it is exposed on the top of the bank just north of the village, and also in the lower part of Bishop Hagg Wood.

In Hutton Beck, just where the main road crosses, it is very well seen, and the complete section may be traced from the limestone up into the Kimeridge Clay.

Section measured in Hutton Beck.

	ft.	in.
Black Shale crowded in places with *Vermicularia* -		
Grey mottled sandy beds - - - -	2	6
Soft reddish sandstone with fucoids - - -	4	0

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	ft.	in.
Ochrey sandy beds containing *Goniomya-v-scripta, Ammonites biplex,* and large plant-like concretions -	8	0
Sandy beds more evenly bedded with *Pecten fibrosas* and *Serpula intestinalis* - - - - -	5	0
Hard grey fossiliferous limestone with *Cerithium* -	—	

Beyond Kirkby Moorside this rock forms a somewhat larger spread, and many fine sections are exposed in it, the most notable being the railway cutting near Kirkdale, where many fine Ammonites are said to have been procured; the bed of the river at Tilehouse Bridge; and the high road at Nawton.

At Helmsley the outcrop is thrown to the west by the east and west fault there, and is seen along the road going to Rievaulx; it is here rather nodular and somewhat similar to the ball bed of the Lower Calcareous Grit. There are several outliers of the rock in Duncombe Park, where the outcrop turns to the south and more or less follows the line of the York road to Oswaldkirk.

The Upper Calcareous Grit forms a considerable spread about here, and dipping to the north occupies nearly the whole surface of the hill. From Oswaldkirk the outcrop extends eastward to the railway cutting at Nunnington Station, where is exposed one of the finest sections in this rock to be found anywhere in the whole of Yorkshire. The rock is here very massive and blue-centred, and exhibits the tendency to run into lines of balls or doggers, mentioned as occurring at Helmsley.

From this point the outcrop follows the northern slope of the hill by Nunnington to the end of the promontory at Ness, where it finally sinks beneath the alluvium of the valley, and when it appears again to the south is so altered lithologically as not to be recognizable as the same rock.

The Southern Region (the Howardian Hills).

Throughout this range of hills in a general way there are only two well-marked divisions of this group of rocks, the Calcareous Grit and the Oolitic Limestone above; the several alternations of grits and limstones previously described having either thinned out or become very obscure, and it is only on palæontogical evidence that we can hope to correlate the limestone of Malton with those of Pickering.

The Calcareous Grit.—In this region the Calcareous Grit first appears in the picturesque nose of Gilling Park; it here appears to correspond in thickness and general position with the same beds on the opposite sides of the valley at Ampleforth, but the thin band of oolitic limestone, dividing the Lower from the Middle Grit, which was already excessively thin at Ampleforth, we have been unable to discover on this side. It would therefore appear that at this, the western end of the range of hills, the grit is really the equivalent of both the Lower and Middle Calcareous Grits of the north, but when we get to Appleton-le-Street and the eastern end of the range, this is not the case, and the Middle Calcareous Grit, if it exist at all, occurs at a considerably higher horizon.

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From Gilling Park the Calcareous Grit is traceable for some distance on either side of the hill to within about a mile of Hovingham Spa. At this point a large fault, which is probably to some extent the cause of these mineral waters, elevates the beds to the south so that we find the Calcareous Grit capping the hill at Hovingham High Wood and forming a series of bold escarpments by Bank Wood, South Wood, Fryton Wood, Slingsby Bank Wood, Coneysthorpe Bank Wood to Easthorpe. It is here somewhat interrupted by faults, and being depressed to the south outcrops again at Head Hag and Mill Hill, and also in the western part of Castle Howard Park, where it forms the fine escarpment of Cumhag and Owlers Woods, and dipping to the north west forms a large spread between this point and the Great Lake. There is here a very famous quarry in the grit from which most of the stone was obtained of which Castle Howard is built, and which is also remarkable for the abundance of aptychi of Ammonites and the phragmacones of Belemnites which it contains. From this quarry I was fortunate enough to obtain a specimen of *Ammonites perarmatus* with the aptychus in position of growth. The following list was also collected at this quarry :—

Fossils from Park Quarry, Castle Howard.

Collyrites bicordatus. Lestre.
Holectypus depressus. Lam.
Rhynchonella obsoleta. Sow.
——— *Thurmanni.* Voltz. (*concinna*).
Gryphœa dilatata. Sow.
Exogyra nana. Sow.
Pecten vagans. Sow.
Modiola bipartita. Sow.
Ammonites perarmatus. Sow.
——— *plicatilis.* Sow.
——— *biplex.* Sow.
——— *cordatus.* Sow.
Belemnites abbreviatus. Mill.
——— *hastatus.* Montf.
Nautilus hexagonus. Sow.

Beyond Easthorpe the Calcareous Grit is cut out by the Hildenley faults, but, coming in again at Musley Bank, is traceable as far as Malton, where it is largely quarried for freestone.

At Appleton-le-Street these beds are brought up by a roll of the strata, and are well seen in several quarries near the village.

On the hill top to the south of Slingsby, and in the valley near Wath there is a thin band of oolitic limestone, the outcrop of which can be traced for about two miles; this limestone may be a thin representative of the Lower Limestone, but there is too much faulting about here to be sure of the exact position occupied by this bed.

The Passage Beds.—Between the Calcareous Grit and the Limestone throughout the Howardian district there are a few

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feet of oolitic gritty beds which constitute a sort of passage between the two; these should probably in part be correlated with the Passage Beds mentioned above, although they can scarcely be said to be identical in all cases. They are not more than a few feet in thickness, and are composed of calcareous grits and sandy limestone with oolitic grains; they contain the following characteristic fossils, *Pecten fibrosus*, *Avicula ovalis*, *Rhynchonella Thurmanni*, *Echinobrissus scutatus*, and *Millericrinus echinatus*. These beds are seen at the base of the limestone wherever a fairly good section occurs; but on account of their extreme thinness, and the outcrop being frequently in a steep bank, they have not been shown by a distinct colour on the map. At the western end of their outcrop about Gilling these beds appear to correspond in position with those on the opposite side of the valley at Ampleforth and Oswaldkirk, that is at the base of the Upper Limestone, and above the Middle Calcareous Grit, but when we get to the eastern end of their outcrop, about Appleton-le-Street, and Malton, they appear to lie at a lower horizon, and certainly occur at the top of the Lower Calcareous Grit; whether this apparent discrepancy is owing to the thinning out of the beds in the intermediate area, or to the difficulty in tracing the lines across the faulted area in the hill top south of Slingsby, there is not sufficient evidence to say.

These beds are quarried for road-metal at Appleton-le-Street, and on the hill east of Coneysthorpe, but they are not of much importance in this map; in the country to the south, about Langton, they are better developed, and will be further described in treating of that country.

The Coralline Oolite.—This division, which may represent both the Upper and Lower Limestones of the north or may be only the equivalent of the upper bed, is first seen in the southern region capping the hill edge east of Gilling. It is here a massive very fossiliferous limestone becoming coarsely oolitic in its upper part, the whole surmounted by a considerable thickness of Coral Rag, with fine *Thecosmilia*. The Coral Rag is well seen about Cawton, where there is a peculiar pisolitic bed in the upper part. From the low ground about the Spa the limestone is thrown up, and crops out in the higher part of Hovingham Park; but, having a rapid north-east dip, it follows the slope of the hill, and has been quarried in the lower part of the park. The limestone is here softer and more homogenous, and has been worked in tunnels, as a freestone, probably for building purposes, beneath the harder beds. From this point the limestone may be traced along the range of hills to the south of Hovingham, Slingsby, Barton, and Appleton-le-Street to Malton, being quarried at a number of places in the neighbourhood of these places.*

* Mr. Hudleston considers the limestone between Barton and Malton to be the equivalent of the Lower Limestone of the Pickering district. Upon palæontological grounds this certainly appears to be the case, but the stratigraphical evidence is unfortunately not sufficiently clear to justify such divisions being drawn. Mr. Hudleston gives a very exhaustive description of these rocks in his paper on the Corallian Rocks. Quart. Journ. Geol. Soc., Vol. XXXIII., p. 361.

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In the neighbourhood of Hovingham, the Coral Rag portion of the limestone is well developed and continues as far as Slingsby, beyond this it has been removed by denudation for some distance, and does not occur again till we reach Malton.

At Hildenley, there is a peculiar limestone which upon palæontological grounds appears to occupy the position of the Rag; it is a very smooth-grained homogenous stone, and on that account much prized for carved work.

The characteristic fossils at Hildenley are *Cidaris florigemma, Modiola cancellata, Lucina aspera* and *Ammonites varicostatus*, which show that the rock is the equivalent of Coral Rag of other places or at least high in the series.

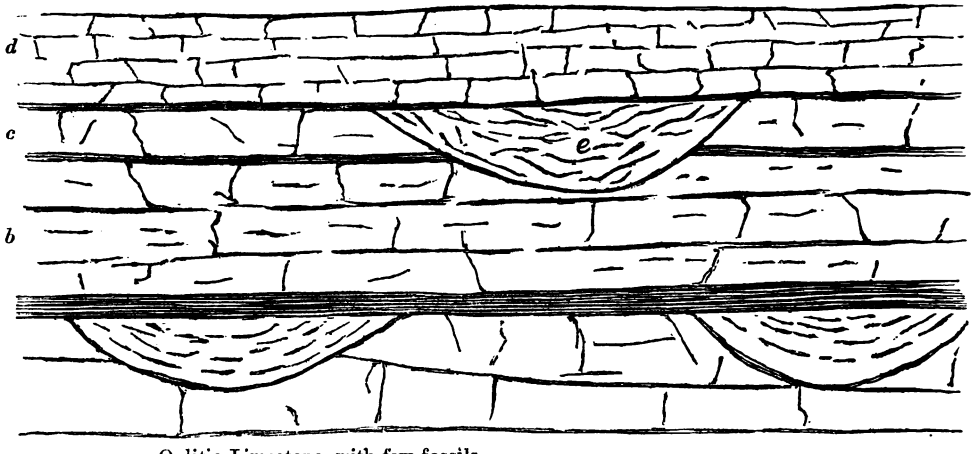
The Coral Rag also outcrops in the faulted outlier at Coneysthorpe, where it is let down by the great east and west fault running between Wiganthorpe and Easthorpe, which truncates it off very sharply on the northern side. The following list of fossils was collected in the limestone quarry behind the village:—

Cidaris florigemma, Phil.
Pseudodiadema mammillanum, Röm.
Gryphœa dilatata, Sow.
Pecten vagans, Sow.
Ammonites perarmatus, Sow.
——— *biplex*, Sow.
——— *triplex*, Sow.
——— *Achilles*, D'Orb.
——— *plicatilis*, Sow.

The following sketch of a quarry near Swinton is interesting as showing that the Oolite was frequently subjected to denudation during the period of its deposition.

FIG. 2.

Limestone Quarry, near Swinton.



a. Oolitic Limestone, with few fossils.
b. Oolitic Limestone, full of *Chemnitzia Heddingtonensis.*
c. Oolite in a solid bed.
d. Broken Oolite.
e. Flaggy, false-bedded Oolite, full of *Ostrea.*

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The Upper Calcareous Grit.—At Hildenley there is a peculiar stone which from its position and from the fossils which have been found in it at North Grimston, in the next map, must be the equivalent of the Upper Calcareous Grit of other places. The rock is a peculiar argillaceous sandy limestone, and is seen in the low bank immediately east of the garden at Hildenley Hall, where also it was proved in digging the foundations of the hothouses. It is apparently a narrow strip either let down between two faults or turned up beneath the Kimeridge Clay by a fault ranging between the gardens and the hall.

This is the only outcrop of the rock in this map; it is much better exemplified in that to the south, at North Grimston, and will be treated of more fully in describing the "cement stone" of that place.

Upper Oolites.

Kimeridge Clay.—The Kimeridge Clay is by far the thickest formation, and has the most extended outcrop of any bed with which we have to deal, nearly half the entire area of the map being occupied by shales of this age. Throughout a large part of its range, however, the Kimeridge Clay is covered by a great accumulation of alluvial and lacustrine beds, and rises in a series of more or less isolated hills from the general flat land formed by these newer deposits.

The thickness of the Kimeridge Clay in this district has not as yet been proved, although several boreholes have been made in it, both with the hope of getting water and also in a ridiculous attempt at finding coal.

The following are the boreholes referred to; the first is just beyond the west edge of the map, but as it shows the great thickness of clay in the valley below Ampleforth it is inserted here.

Boring for Major Stapleton, in search of Coal, Low Pasture House, Wass.

	ft.	in.
Kimeridge Clay *	90	0
Stone,† water rising to the surface	2	0
Blue shale	186	0
Hard blue shale	120	0
	398	0

Boring for Water, J. W. Woodall, Esq., Salton.

Sand and Gravel	7	0
Kimeridge Clay*	145	0
Rock	148	7½
	300	7½

* These are the names used by Mr. Owston, to whom I am indebted for the above particulars. It is probable that all the shale is Kimeridge Clay, but we have no means of ascertaining.

† Probably one of the hard bands in the Kimeridge Clay.

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A good supply of water at 210 feet, 4 inches of coal at 215 feet, more water at 220 feet and 263 feet. The rods dropped 3 inches at 282 feet, and abundance of water rose above the surface.

*Boring at Old Malton.**

(Particulars generally taken at intervals of five feet).

	ft.	in.
Sand - - - - - - -	5	0
Clay - - - - - - -	4	0
Gravel - - - - - - -	8	0

At 17 to 55 feet, hard dry clay with white specks to 150 feet.
At 60 feet, a stone, supposed Septaria, about 12 inches thick. The hole full of water to within two or three feet of surface.
At 65 to 145 feet. Hard dry clay with white specks.
At 150 to 170 feet. Clay changes to pure black and plastic, and becomes gradually softer. Tool almost sank with its own weight.
„ 175 feet. Clay hardens; some Pyrites; water comes to the surface.
„ 180 „ Clay, as before.
„ 185 „ „ „
„ 190 „ „ softer, and mixed with grey colour of the Oolite.
„ 195 „
„ 200 „ „ black.
„ 205 „ „ „
„ 210 „ „ soft and moist.
„ 215 „ „ dry and white specks again.
„ 220 „ „ „ „
„ 225 „ or rather above. Hard strata requiring drill, say, about 12 inches, and the clay very soft under it, but again becomes very dry and friable.
„ 232 feet. A small strata of red sandy matter, a few inches.
„ 245 „ Clay plastic.
„ 250 „ „ no white specks.
„ 260. Stone, hard to drill, about 12 to 18 inches.
„ 265 to 330 feet. Clay, as above.
(At 300 feet, or rather above, two or three inches of hard bed.)
„ 335 „ Hard clay, with white specks and some pimples of spar.
„ 340 „ „ „ „
„ 345 „ Hard clay, jetty; at 348 a hard band, which required the drill; only three or four inches thick.
„ 353 feet. Clay, hard, with large white patches size of a pigeon's egg, and like salt, but tasteless. Clay easier to work.
„ 367 feet. Hard strata; had to use drill. Say about 8 inches thick.
„ 370 to 400 feet. Clay, hard, black and dry; very hard to work.
„ 405 feet. Clay, hard and black. Jetty as before.
„ 410 „ Hard strata, about 8 inches. Had to use drill.
„ 415 to 425 feet. Hard clay, with white flakes.
„ 430 „ Hard and black, with white specks, and part very white, almost pure lime. Jetty looking.
„ 436 feet. Black with white streaks.
„ 447 „ Black, and no white in it. A small pebble.
„ 453 „ Came at a hard stone which they were more than two weeks in going through; only 4 or 6 inches thick. The portion brought up showed clear spar and pyrites.
„ 468 feet. Another hard stone similar to the last. The rods too weak and the boring abandoned.

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* I am indebted for the details of this section to Mr. Henry Hartley, of Malton. Mr. Hudleston gives an abstract of it, Proc. Geol. Assoc., Vol. V., p. 47.

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Boring at Mr. Fosters, Norton.

(Canal House, on Ordnance Map.)

	ft.	in.
Soil and sand - - - - - - -	40	0
Soft clay - - - - - - -	60	0
Hard black clay with boulders,* occasionally from 12 to 18 inches thick. No water and the boring abandoned	260	0
	360	0

All these boreholes, with the exception of that at Salton, are within about 500 yards of the Oolites, thus showing the presence of large faults in their immediate neighbourhood.

The principal hills in the centre of the map formed by the Kimeridge Clay are at Kirkby Misperton, Great Barugh, Salton, South Holme, Red Hall, Normanby, Edston, near Sinnington and near Helmsley.

At Thornton Dale the Kimeridge Clay is faulted against the Oolites, but rises gradually with the dip at Sinnington and Kirkby Moorside, the actual junction being seen in Hutton Beck near Sinnington Manor House; about here it is spread over the Oolite in several isolated patches, which attain an altitude of as much as 400 feet.

To the north of Helmsley it is again faulted against the Oolite, but to the south it rises regularly over the inferior beds, and crops along the flanks of the Oolites from Sproxton to Nunnington.

Between Oswaldkirk and Gilling it is let in by the great trough faults on either side of the valley, and is well seen at several places forming small scars in the sides of the hills south of Ampleforth.

East of Gilling the Kimeridge Clay is not exposed, unless a little clay seen near Cawton and in Hovingham Park should represent it.

The Kimeridge Clay again outcrops in a narrow strip to the south of Hildenley, where it is let in between two faults extending as far as the great lake in Castle Howard Park, and also on the steep slopes below the Chalk at Scagglethorpe and Settrington.

The brickyard at Hildenley and the steep slopes about Settrington are the best and most fossiliferous exposures in this formation.

Mr. Hudleston mentions the following species from Hildenley:—†

Ammonites mutabilis, Sow.
Alaria mosensis, Buvig.
Ostrea deltoidea, Sow.
Exogyra nana, Sow.
Avicula (*œdiligensis*), Blake.
Trigonia (clavellate sp.).
Thracia depressa, Sow.
Myacites oblatus, Sow.
Pholadomya, sp.

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* Probably Septaria or the hard bands in the Kimeridge Clay.

† Quart. Journ. Geol. Soc., Vol. XXXIII., p. 372.

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To these the following, which have been found near Kirkby Moorside and near Settrington, may be added:—

Ammonites cordatus, Sow.
„ *Lamberti*, Sow.
„ *biplex*, Sow.
Avicula expansa, Phil.
Exogyra subsinuata, Sow.
Ostrea flabelloides, Lam.
Pecten subtextorius, Münst.
Cucullœa.
Astarte lineata, Sow.
Lucina Portlandica, Sow.
Thracia depressa, Sow.
Discina latissima, Sow.

The Kimeridge Clay has been worked for making bricks at Kirkby Moorside, Nawton Grange, Wass Grange, Hildenley, and Scagglethorpe, but very few, if any of them, are in operation now.

CRETACEOUS ROCKS.

The Red and White Chalk.—As the Cretaceous Rocks scarcely enter this map, we need not devote much space to their description.

The Lower Cretaceous beds, as represented by the Speeton or Neocomian clays, are entirely overlapped by the Chalk before they reach this district, so that the Chalk reposes directly on the Kimeridge Clay.

The Red Chalk has a thickness of from 10 to 15 feet, and is succeeded by yellowish nodular beds, which in their turn are succeeded by white chalk, with red and white variegated bands. These beds outcrop in the steep bank at the summit of the hill above Scagglethorpe and Settrington, and were well exposed at one point near the former village, where the above succession was made out, the red beds being crowded with *Belemnites minimus*, *Inoceramus sulcatus*, &c.

The White Chalk, which occupies the summit and surface of the hill, has no great thickness in this map. It constitutes the north-west corner of Thorpe Basset Wold, and represents merely the basement beds of the Chalk formation, or the Lower Chalk without flints.

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SUPERFICIAL DEPOSITS.

Boulder Clay and Gravel.—The principal area of Boulder Clay is in the south-west of the map, in the low ground between Crayke and Brandsby. It here has a thickness of from 45 to 60 feet, as has been proved in one or two wells sunk near here. The following well sections were obtained from this neighbourhood :—

Broad Oak.

	ft.	in.	
Old well - - - - -	30	0	
Sand - - - - - -	4	0	
Clay, with cobbles - - - -	50	0	
Shale - - - - - -	36	0	
Total boulder clay and sand - -			84 0

Near Brandsby, two miles from Stillington, clay and stones 45 feet.

This Boulder Clay is confined almost entirely to the low ground, and rarely rises above the 350 contour. It is composed chiefly of the usual stiff clay, with erratics, and there is not very much gravel, except at Brandsby, and just beyond the limit of the map at Whenby.

There are two local patches of drift on the hills above Adams Hall and Hollin Hill, but they are very thin and not of much importance.

Over the central portion of the map there is a certain amount of Boulder Clay and Gravel which caps most of the hills lying in the plain; its thickness at Kirkby Misperton and Barugh is about 7 feet. It thins out towards the sides of the hills, and does not appear to be present to any great extent under the alluvium in the lower districts, as far as we can judge from those borings which have gone down to the Kimeridge Clay. On some of the hills, as at Kirkby Misperton, there is a considerable deposit of gravel, which gives rise to several springs, and which is of considerable importance to the villages, as being the only source from which they can obtain good water.

Sections were exposed in some of the cuttings in the railway between Helmsley and Pickering which showed that the Boulder Clay was never more than a few feet thick, and rarely so much as that.

At the top of Cropton Banks Wood, and near Kingthorpe House, are two isolated patches of Drift, which are all that we know of occurring above the level of the Kimeridge Clay.

In the Pickering and Scarborough railway, which is now being made, a fine section of Boulder Clay is seen in the cutting just south of Thornton Dale. It here has a thickness of over 25 feet, and is composed entirely of materials derived from the immediate neighbourhood, chiefly, in fact, of large doggers from the Calcareous Grit and masses of black shale from the Kimeridge Clay, which do not seem to have been exposed to either much crushing or rolling, and cannot have been carried very far.

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Warp and Lacustrine Clay, Sand, and Gravel.—The whole of the central, low-lying plain is covered with these sands and clays, which, as will be seen from the subjoined list of wells and bore-holes, are of considerable thickness.

Sinnington Station.

	ft.	in.
Clay	15	0
Shale	6	0
	21	0

Gate House near Pickering Junction.

	ft.	in.
Clay	6	0
Gravel	18	0
	24	0

Black Bull, near Brignam Park.

Clay and sand - 14 ft. 6 in. or more, not total depth.

Near Charity Farm.

Clay and sand - 40 ft.

Bellifax Grange.

	ft.	in.
Soil	2	0
Clay	4	0
Quick sand	6	0
Soft clay	40	0
Hard black clay	8	0
Slate and gravel	7	0
	67	0

Scampston Bogs.

	ft.	in.
Soil sand	6	0
Clay	6	0
Quicksand	4	0
Clay	5	0
Quicksand	6	0
Soft clay	55	0
Sand and clay	4	0
Sand and gravel	16	0
Soft clay, leafy	5	6
	107	6

Wath House.

	ft.	in.
Loam and sand		
Shale		
Clay		
Gravel		
Clay		
Total	90	0

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Near Golden Square (two wells).

Clay and sand	70 and 90 ft.

Boring at Howe, neur Malton.

	ft.	in.
Sand	4	0
Good clay	10	0
Shale ? Laminated clay	80	0
"Sea gravel"	3	0
Black shale	63	0
Total superficial deposits	97	0

Boring at Espersikes.

Clay and sand	60 ft.

Boring at Old Malton (north side of village).*

	ft.	in.
Sand	5	0
Clay	4	0
Gravel	8	0
	17	0

Boring at Old Malton (in Westgate).

	ft.	in.
Sand		
Clay		
Sand		
Gravel		
Clay		
Gravel		
Clay		
Stone		
Gravel		
Oolite rock, about 2 ft. gone into		
Total	28	0

Well at Leng's Cottage, near Parnham House.

	ft.	in.
Sand	4	0
Clay	3	0
Sand	2	0
Clay	50	0
Grey sand	2	0
Black shale below.		
	61	0

Water rises to the surface.

Well at Parnham House.

Clay and sand	80 ft.

Well at Manor House.

Clay and sand	60 ft.

* The rest of this section is given in detail, p. 24.

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Well at Shortten Hall.

Clay and sand - - - -	70 ft.
White gravel at bottom.	

Great Habton.

	ft.
Sand and clay - - - -	10
Black shale - - - - -	130
	140

By a careful comparison of the depth of these different wells, it is possible to make out roughly the contour of the old valley below these accumulations.

Throughout the greater portion of this great valley clay lands predominate, especially over all the area between Thornton Dale and Slingsby; the principal spreads of gravel being at Pickering, along the valley between Slingsby and Gilling and the great terrace south of the Derwent, between Norton and Settington; in this latter district the clay underlays the gravel as may be seen in the brickyards near the Malton Station, where there is from 8 to 10 feet of falsebedded sand and gravel over clay.

The clay is usually finely laminated, and in most cases forms a very good material for brickmaking. The following sections obtained from the brickyard in this district afford an insight into the nature of this deposit.

Clay Pit, near Brignam Park, Pickering Low Carr.

	ft.	in.
Yellow clay - - - -	3	0
Blue clay - - - - -	1	6
Sand - - - - -	1	0
Blue clay* - - - - -	4	6
Loam - - - - -		
Sand - - - - -	4	6
Clay, unknown depth.		

Clay Pit, Low Moor, Rillington.

Half a mile north of the station.

	ft.	in.
Soil - - - - -	1	0
Loam - - - - -	1	6
Clay - - - - -	5	6
Sand - - - - -	7	0
Clay (Laminated) - - - -	5	6
Sand - - - - -	2	0
Clay (Laminated) - - - -	14	0
Sand (bored into) - - - -	3	0
	39	6

The bottom clay is the most laminated. The middle clay is the best for brickmaking.

* Laminated clay, very good for brickmaking; the brickyard east side of railway has 9 feet of sand, and no laminated clay.

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Brick and Tile Works, Slingsby.

	ft.	in.
Sand and loam	4	0
Laminated clay	11	0
Sand	2	0
	17	0

Brickyards near Barugh.

	ft.	in.
Sand	3	0
Clay	4	0
	7	0

This is the only clay worked in these pits, the workmen cannot get lower on account of water.

There is the same peculiarity with regard to the gravels in this district as we noticed in the country to the east, that they are composed almost entirely of the neighbouring rocks; thus, those at Pickering are derived from the Oolites generally, those at Malton mostly from the oolitic limestone, those at Norton from the Chalk.

Dry-Valley Gravel.—As is usual in a country where porous rocks occupy a large area of the surface, we have several dry valleys with an accumulation of sand and gravel along their bottoms: such valleys occur at various points along the range of hills from Pickering to Helmsley. There is also a dry valley running north and south through the town of Malton, but this appears to be the remnant of an older contour; it contains a thick deposit of gravel which is very falsebedded and highly inclined in places as if it had been rearranged since its original deposition.

Alluvium.—Most of the principal rivers have a strip of modern alluvium along their banks which is at a lower level than the surrounding flat. This alluvium is well marked along the River Derwent and up the Rye as far as Newsham Bridge, but above this it frequently becomes blended with the general spread of lacustrine deposits, so that it is only in some cases the two can be separated from one another. For instance, the river Leven, after issuing from the gorge at Sinnington, does not form an alluvium which is separable from the general clay flat of the Vale; and below Normanby, instead of being below that level, is at a higher elevation, so that it has to be confined by artificial banks from overflowing the surrounding land.

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Physical Structure.

Lie of the Rocks, Faults, etc.—The general contour of the ground in this map assumes roughly, as we said above, the shape of a horse shoe; the most elevated ground being in the north, west and south, with a low lying and comparatively flat area in the centre and towards the east; and it will be seen that the general dip of the strata turns round in the same manner as the range of hilly ground.

Commencing along the northern edge of the map we find that the dip of the several beds is southerly, at angles of from two to five degrees, varying from nearly south-west at Thornton Dale to south-east in the neighbourhood of Helmsley; at this latter place the beds curve round rather sharply, and to the south of the town, on the high ground towards Ampleforth Moors are dipping north-east at an angle of about four degrees.

As we approach the escarpment at the foot of which the villages of Ampleforth and Oswaldkirk stand, the dip again changes, becoming nearly north by east. Crossing the valley between here and Gilling, in which the strata have been let down between trough faults, the beds do not appear to have any considerable dip, and we find the same general direction, or about N.N.E. continued along the Howardian range of hills to Malton.

A glance at the map will show that the outcrop of the strata along the north is very regular, that there are but few faults, and that the several beds strike from east to west with scarcely any interruption, but on turning to the southern range of hills we see a very different state of things; here the whole country west of Malton, over a breadth of about four miles, is intersected by faults, some of them of considerable amount, which either terminate the outcrop of large series of strata, or else repeat them. It appears that a great east and west dislocation has at some time taken place, which, finding the strata thinnest and also weakest along the Howardian range of hills, has shattered them, causing the irregularity of outcrop we observe, and thus has given rise to one of the most intricate pieces of geology in north-east Yorkshire.

The general structure of the country divides itself into three areas; the central low-lying and more or less flat ground to the north of Malton; the range of hills north and west of Pickering and south of Helmsley, and the Howardian hills west of Malton.

The first and second of these areas are a continuation of the country described in the memoir on 95 S.W., the first being the western half of the great depression known as the Vale of Pickering. This ground, which covers an area in this map of nearly 80 square miles, is over a large part covered by superficial accumulations of Boulder Clay and Alluvium, which, in some places are as much as 90 feet in thickness: out of this plain of alluvium rise several isolated hills of Kimeridge Clay, the principal of which are those at Kirkby Misperton, Great Barugh,

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Salton, Normanby, Edston, Riseborough, and those near Thornton Dale and Helmsley.

The Kimeridge Clay appears to lie tolerably flatly over this valley, but as the sections in it are but few it is not easy to say whether it is much faulted or otherwise disturbed.

The second area includes the hills on the north, and is, as we have said, a continuation of the range of Middle Oolites running from the coast at Scarborough. The rocks in this district dip regularly beneath the Kimeridge Clay of the valley throughout a great part of their course, but this regularity is however disturbed at a few places.

At Thornton Dale there is a large east and west fault which brings in the Kimeridge Clay, on which the greater part of the village stands, sharply against the underlying Oolites, outcropping on the high ground to the north. The amount of displacement caused by this fault there it no means of judging, as the base of the Kimeridge Clay has never to my knowledge been proved. There is a very deep well within a few yards of the outcrop of the Oolitic Limestone, but it is very possible that this well went through the hade of the fault, and thus penetrated to water bearing strata without reaching the base of the Kimeridge Clay. The limestone also seen in the quarry close by at the side of the road to Lockton is somewhat faulted and disturbed at its southern end. This fault is probably continued to the south of Pickering, and the underground river which issues at Keld Head may in some measure be due to it.

At Ellerburn there is a small branch of this fault which can have no very great throw, but which the somewhat obscure nature of the ground about there renders necessary.

At Sinnington there is a well marked fault running to the north west and having a downthrow on the west side of about 100 feet. This fault is very noticeable along the valley immediately north of the village, the Oolites on the east rising in a steep precipitous bank, while the Kimeridge Clay and Upper Calcareous Grit on the west are seen on lower ground and dipping towards them. On tracing this fault to the north it is equally manifest for some distance, and where the river makes the large bend about half a mile north of the village the Coral Rag is seen on the west side, 100 feet lower than its outcrop on the east. At Appleton-le-Moor part of the gardens on the west side stand on Kimeridge Clay, while the houses are on Limestone, and north of this the break in continuity of the beds is very apparent. This fault is lessening in throw towards the north, and just beyond the map, after cutting the great escarpment above Lastingham, appears to die out.

There is a small branch of this fault with a downthrow to the south, which is seen in section at the south end of the quarry, just above the village of Sinnington, it throws the Upper Calcareous Grit against the Coralline Oolite, but there is no evidence of its extending for any distance.

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Near Pockley there is a long strip of Kimeridge Clay thrown in by a fault having a downthrow on the east. This fault is very apparent as far as Pockley, but north of this it appears to die out. Its southern end joins with an east and west fault along the roadside above Beadlam Grange. The east and west fault, which is parallel with the road for a short distance, has a marked effect on the rocks exposed in an old quarry at the roadside where the dip of the beds to the south suddenly increases from 3 to 12 degrees. West of this the Kimeridge Clay is seen in the bed of the river Riccal, about 200 yards above the bridge, abutting against the sandstones of the Middle Calcareous Grit. North of Helmsley the fault may be traced by the abrupt termination of the Kimeridge Clay, &c., against the beds of the Middle Oolites, but beyond this its course is not so marked, although it causes a dip of 18 degress in a quarry near Griff, and also some irregularity in the mapping of the beds in the bank south of Rievaulx. This fault is seen in the river Rye, about 260 yards above Rievaulx Bridge, but beyond this it is not traceable, although it probably coincides with the opposite dale for some distance.

There are a few small faults also in this area, near Pickering, in the valley of the Dove; and at Kirkby Moorside, but they are only of minor importance, and do not extend for any great distance.

Passing to the south the beds are undisturbed until we come to the Ampleforth escarpment, where we may be said to enter our third area, the faulted district of the Howardian Hills. In this district all the main faults are more or less east and west, and the principal of these seem to be those which bound the Kimeridge Clay. Starting on the north side are the two faults which bound the valley traversed by the Thirsk and Malton Railway, on the north and south, and which being down towards each other have formed a trough in which the Kimeridge Clay lies to an unknown depth.

The northern of these faults ranges along the base of the Ampleforth escarpment by Oswaldkirk and Stonegrave; its exact position may be fairly well fixed by the juxtaposition of the Kimeridge Clay, with beds of the Lower Oolite near Wass, and with the Middle Oolite at Ampleforth; this latter village stands on a rubble of Calcareous Grit, fallen from the hill above, so that the line is rather obscure near here, but at Ampleforth College, where wells have been sunk into the clay, it becomes more distinct. At Hag House the black shales of the Kimeridge Clay are seen on the north side of the road, close to a well which was sunk 34 feet in sandstone without finding water; beyond this the line of fault nearly follows the road as far as Oswaldkirk Hall, where is a well sunk 42 feet in shale close to the great bank of Calcareous Grit and Coralline Oolite. Beyond Oswaldkirk the clay creeps further up the bank, and may be seen in the fields beyond Laysthorpe Lodge, nearly to the summit of the hill, the junction with the Oolite being very sharp and well defined. At Stonegrave this fault appears to split into two parallel branches, the southern one keeping along the foot of the hill and bringing in the Kimeridge

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Clay at its base, the northern branch ranging along the hillside and repeating the Coralline Oolite and Passage beds at Stonegrave, and the Upper Calcareous Grit beyond Cauklass Grange. To the north of South Holme these faults probably unite again; but how far they may extend in an easterly direction there is no means of judging, as they become lost in the alluvium of the valley.

The fault on the south side of the Gilling valley cannot be traced quite so exactly as that just described, but its general position is not difficult to make out. Along the northern side of Newborough Park the Lower Oolites are cut off sharply by this fault, and the Kimeridge Clay, which is here obscured by Drift, is brought against them. In the neighbourhood of Gilling the fault is obscured by the alluvium, but its position will probably be close below the bank on which the Castle stands. At Cawton and Hovingham a little clay is seen, which may be the weathered surface of the Kimeridge Clay coming out on the north side of the fault. Beyond this the fault ranges along the foot of the hills through the villages of Slingsby, Barton-le-Street, Appleton-le-Street, and Amotherby, to Old Malton; throughout this part of its course the fault is covered by alluvium, and I have not been able to obtain any information to enable me to trace its course very definitely. At Old Malton, however, its position can be again fixed, for a well sunk at the side of the lane leading to Rainbow House was in Oolite Limestone, while the borehole, 360 yards north of this spot, went 468 feet in the Kimeridge Clay without finding the bottom. Again the Oolite Limestone is seen in the bed of the River Derwent, just above the Doodales, dipping at a high angle, and ending off so sharply a little further up the stream in deep water as to form a very dangerous place for bathers. There is a quarry in Oolite Limestone on the roadside near Norton Parks, which will not be far south of the line of fault, but beyond this it becomes lost under the alluvium, and there is no means of tracing it. It is possible that this fault affects the Chalk to the south of Thorp Basset in the next map, and may be the cause of the disturbances noticed between there and Weaverthorpe.

The next fault with which we have to deal is that south of Gilling Park. This may be said to commence at the valley called Heron Gill, in Newborough Park, for there is not much evidence for it west of this; it runs nearly due east with a gradually increasing amount of throw across Yearsley Moor where the limestones outcropping in the upper part of the hill are repeated in the lower; east of this the Middle Oolite of Gilling Park is thrown against the Lower Oolite, and a little further the limestone of the Coraline Oolite is actually touching the celebrated roadstone quarry of the Lower Oolite at Low Warren House. Beyond this, at Stocking House, the Calcareous Grit is seen dipping at an angle of about 30 degrees to the north away from the fault, and occurs at a level of nearly 200 feet lower than its outcrop in Hovingham High Wood to the south; from this

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point the fault follows down the valley to Hovingham Spa where it unites with the great east and west fault previously described, the union of these two faults very probably giving rise to the mineral waters at this place. There are two small branches of this fault on its northern side, and also one at Cawton which shift the limestone to some extent, but are not otherwise of much importance. On the south side, however, there is a branch fault also throwing down to the north which bounds the outcrop of the roadstone at Piper Hill, Blackdale Plantation, and north of Colton.

In the neighbourhood of Brandsby is another fault which is a continuation of one running through the town of Easingwold, in map 93 N.W., where the Keuper and Rhætic beds on the south are thrown against the Middle Lias on the north. In this map, its effect on the Liassic Rocks is not very apparent on account of their outcrop being so much obscured by Boulder Clay, but it is very evident that a fault exists here, the Middle Lias at Crayke being at a much higher level than that seen near Britton Wood, and this last is certainly much thrown forward when compared with the outcrop of the same beds east of Brandsby. When, however, we reach the Oolites the displacement becomes much more marked, the Grey Limestone being nearly on a level with the base of the Oolites in High Wood, and the Millepore bed forming an outlier on the south which is 150 feet higher than the outcrop of the same bed on the north, beyond this the fault ranges east to Scackleton Grange, but from the want of any sections about here becomes more obscure; from this point it bends round to the north causing a reverse or southerly dip in a quarry near Scackleton, and a slight break in the beds as far as Wool Knowl when it appears to die out.

At the point near Scackleton where this last fault makes its great bend another main fault takes its rise, which would seem to be a continuation of that from Brandsby were it not that the throw is down to the south or in the opposite direction. This fault, which ranges along the north of Wiganthorpe, causes a marked depression in the beds on its south side which cannot fail to be observed in crossing it at almost any point, in fact it is the most marked and easily recognized of all the faults in the district. South of Scackleton it throws beds below the Hydraulic Limestone against the upper part of the Grey Limestone, and an inlying portion of the Dogger and Lias crops up at the back of the fault near Wiganthorpe House. Beyond the valley going down to Wath the fault becomes even more apparent, the great escarpment of the Lower Calcareous Grit being thrown forward, and nearly the whole series of Lower and Middle Oolite repeated over again, so that at Coneysthorpe the Coralline Oolite is on a level with beds below the Millepore. East of this the fault dies out very rapidly, and it is doubtful if it extends beyond Easthorpe, although there is a fault with the same throw and running in the same direction by Tricky Castle to Musley Bank, which depresses the limestone on the south at these places.

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At Terrington is another east and west fault, which, breaking the escarpment of Lias and Oolites at Flat Top, more or less follows the road for nearly two miles through the village. By this fault the Hydraulic Limestone which crops at the corner of the road going down to Sherriff Hutton, is thrown out nearly as far as Ganthorpe, and the escarpment of Calcareous Grit is cut off at Owlers Wood; east of this it ranges nearly along the edge of the map, forming a boundary to the Calcareous Grit in this part of Castle Howard Park as far as the Dairies where it unites with a fault bounding the Kimeridge Clay.

This latter fault appears to traverse the Great Lake, and having a down throw to the north-east, cuts out the Coralline Oolite, so that we have a dip slope of Calcareous Grit on the west side of the Lake, and a large spread of Kimeridge Clay on the east. This fault runs along the north edge of the Park, by the Mausoleum in the next map, and curving round as it crosses the Derwent enters this map again to the south of Sutton Grange and traverses the foot of the Oolites by Rectory Farm to Settington, where it is splendidly seen in the railway cutting. It forms the southern boundary of the long inlet of Kimeridge Clay below the alluvium of Norton, while that next to be described forms its northern limit.

The last of the main faults with which we have to deal is one which, apparently uniting with that just mentioned in the Great Lake at Castle Howard, strikes east at the foot of the escarpment by Easthorpe Hildenley, Musley Bank, and on to Malton. It is a downthrow to the south and brings in the Kimeridge Clay in the low ground south of these places; the amount of throw about Hildenley does not appear to be very great, as the highest beds of the Middle Oolite have been found in the gardens at the Hall at only a slightly lower level than that at which, considering the high dip of the Coralline Oolite to the north of the House, they might naturally crop out. Still it is just possible there may be a larger fault to the south between the gardens and the brickyard. At Malton the fault has been proved on the north side of the river, the foundations of the bridge near the Railway Station being in Kimeridge Clay, and clay was also seen resting against the Oolite in digging the foundations of Russell's Brewery. The Lady's Spring which supplies the town with water is also probably on the line of this fault; east of this the fault crosses the river and strikes just north of Canal House where a well sunk 360 feet in Kimeridge Clay failed to reach the bottom, beyond this it probably strikes against the Old Malton Fault, and the two more or less neutralize one another.

At Hildenley there is a branch of this fault which runs just at the back of the Hall, and the principal evidence for which is that some shales upon which the house stands, and which I suppose to be Oxford Clay, although I was not able to find any fossils in them, are within a few yards of the quarry of Hildenley stone. It is just possible that the shales may belong to the supra coralline

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beds, and in that case a fault would also be required, but with a reverse throw.

Of the minor faults there is not much to say. They are rendered evident in tracing out the various beds, but are mostly small, and do not, any of them, extend for any great distance; they are most of them more or less connected with the larger throws and are offshoots from them.

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*Leicestershire, 71 (SW), 63 (NW).
Northumberland and Durham (N. part), 105 (NE & SE).
*North Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
*South Staffordshire. 54 (NW). 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
*Warwickshire, 62 (NE & SE), 63 (NW & SW), 54 (NE), 53 (NW).
Yorkshire, 88, 87 (SW), 93 (SW), &c.

SCOTLAND.

*Edinburgh, 32, 33. *Haddington, 32, 33.
Fife and Kinross, 40, 41., &c. &c.

IRELAND.

*Kanturk, 174, 175. *Castlecomer, 128, 137.
*Killenaule (Tipperary), 146.
(For Sections illustrating these Maps, see detailed list.)
* With descriptive Memoir.

GEOLOGICAL MAPS.

Scale, six inches to a mile.

The Coalfields of Lancashire, Northumberland, Cumberland, Westmorland, Durham, Yorkshire, Edinburghshire, Haddington, Fifeshire, Renfrewshire, Dumbartonshire, Dumfriesshire, Lanarkshire, Stirlingshire, and Ayrshire are surveyed on a scale of six inches to a mile.

Lancashire.

47. Clitheroe.
48. Colne, Twiston Moor.
49. Laneshaw Bridge.
55. Whalley.
56. Haggate. 6s.
57. Winewall.
61. Preston.
62. Balderstone, &c.
63. Accrington.
64. Burnley.
65. Stiperden Moor. 4s.
69. Layland.
70. Blackburn, &c.
71. Haslingden.
72. Cliviger, Bacup, &c.
73. Todmorden. 4s.
77. Chorley.
78. Bolton-le-Moors.
79. Entwistle.
80. Tottington.
81. Wardle. 6s.
84. Ormskirk, St. Johns, &c.
85. Standish, &c.
86. Adlington, Horwick, &c.
87. Bolton-le-Moors.
88. Bury Heywood.
89. Rochdale, &c.
92. Bickerstaffe, Skelmersdale.
93. Wigan, Up Holland, &c.
94. West Houghton, Hindley, Atherton
95. Radcliffe, Peel Swinton, &c.
96. Middleton, Prestwich, &c.
97. Oldham, &c.
100. Knowsley, Rainford, &c.
101. Billinge, Ashton, &c.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford, &c.
105. Ashton-under-Lyne.
106. Liverpool, &c.
107. Prescott, Huyton, &c.
108. St. Helen's, Burton Wood.
109. Winwick, &c. 6s.
111. Cheedale, part of Stockport, &c.
112. Stockport, &c. 4s.
113. Part of Liverpool, &c. 4s.

Durham.

Scale, six inches to a mile

Sheet.
1. Ryton. 4s.
2. Gateshead. 4s.
3. Jarrow. 4s.
4. S. Shields. 4s.
5. Greenside. 4s.
6. Winlaton.
7. Washington.
8. Sunderland.
9. ——— 4s.
10. Edmond Byers. 4s.
11. Ebchester.
12. Lantoydy.
13. Chester-le-Street. 6s.
14. Chester-le-Street.

Durham—cont.

Sheet.
16. Hunstanworth.
17. Waskerley.
18. Muggleswick.
19. Lanchester. 6s. Vertical Section, 39.
20. Hetton-le-Hole.
24. Stanhope.
25. Wolsingham.
26. Brancepeth.
32. White Kirkley.
33. Hamsterley.
34. Whitworth.
41. Cockfield.
42. Bishop Auckland.

Northumberland.

Scale, six inches to a mile.

47. Coquet Island. 4s.
56. Druridge Bay, &c.
63. Netherwitton.
65. Newbiggin. 4s.
68. Belingham.
69. Redesdale.
72. Bedlington.
73. Blyth. 4s.
77. Swinburn.
78. Ingoe. 6s.
80. Cramlington.
81. Earsdon.
84. Newborough.
85. Chollerton.
86. Matfen.
87. Heddon-on-the-Wall.
88. Long Benton.
89. Tynemouth.
92. Haltwhistle.
95. Corbridge.
96. Horsley. 4s.
97. Newcastle-on-Tyne.
98. Walker. 4s.
101. ———
102. Allendale Town.
105. Newlands.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Allenheads.

Yorkshire.

100. Limley.
184. Kelbrook.
201. Bingley.
204. Aberford.
216. Bradford.
217. Calverley.
218. Leeds.
219. Kippax.
231. Halifax.
232. Birstal.
233. East Ardsley.
234. Castleford.
246. Huddersfield.
260. Honley.
272. Holmfirth.
273. Penistone.
274. Barnsley.
275. Darfield.
276. Brodsworth.
281. Langsell.
282. Wortley.
283. Wath upon Dearne.
284. Conisborough.
287. Low Bradford.
288. Ecclesfield.
289. Rotherham.
290. Braithwell.
293. Hallam Moors. 4s.
295. Handsworth.
296. Laughton-en-le-Morthen.
299. ———.
300. Harthill.

SCOTLAND.

Scale, six inches to a mile.

Edinburghshire.

2. Edinburgh, &c.
3. Portobello, Musselburgh, &c.
6. Gilmerton, Burdie House, &c.
7. Dalkeith, &c.
8. Preston Hall. 4s.
12. Penicuick, Coalfields of Lasswade, &c.
13. Temple, &c.
14. Pathead. 4s.
17. Brunston Colliery, &c.
18. Howgate.

Haddingtonshire.

Six inches to a mile.

8. Prestonpans, &c. Price 4s.
9. Trenent, Gladsmuir, &c. Price 6s.
13. Elphinstone, &c. Price 4s.
14. Ormiston, East Salton, &c.

Fifeshire.

Six inches to a mile

24. Markinch, &c.
25. Scoonie, &c.
30. Beath, &c.
31. Auchterderran. 4s.
32. Dysart, &c.
33. Buckhaven.
35. Dunfermline.
36. Kinghorn.
37. Kinghorn. 4s.

Ayrshire.

Six inches to one mile.

19. Newmilns.
26. Glenbuck. 4s.
27. Monkton, &c.
28. Tarbolton, &c.
30. Aird's Moss.
31. Muirkirk. 4s.
33. Ayr, &c.
34. Coylton.
36. Grieve Hill.
40. Chiltree.
41. Dalleagler.
42. New Cumnock.
46. Dalmellington.
47. Benbeock.
50. Daily.
52. Glenmoat.

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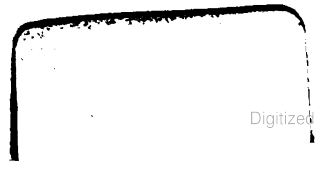

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